Trade wars and trade talks with data

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Abstract: How large are optimal tariffs? What tariffs would prevail in a worldwide trade war? How costly would a breakdown of international trade policy cooperation be? And what is the scope for future multilateral trade negotiations? I address these and other questions using a unified framework which nests traditional, new trade, and political economy motives for protection. I find that optimal tariffs average 62 percent, world trade war tariffs average 63 percent, the government welfare losses from a breakdown of international trade policy cooperation average 2.9 percent, and the possible government welfare gains from future multilateral trade negotiations average 0.5 percent.

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Trade Wars and Trade Talks with Data

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Overview

- I propose a flexible framework for the quantitative analysis of noncooperative and cooperative trade policy
- It takes a unified view of trade policy which nests traditional, new trade, and political economy elements
- I use it to provide a first comprehensive quantitative analysis of noncooperative and cooperative trade policy

Findings

- Each country can gain considerably at the expense of other countries by unilaterally imposing optimal tariffs:
  - Mean welfare gain: 1.9%; mean welfare loss: -0.7%; median optimal tariff: 62.4%
- Welfare falls across the board in the Nash equilibrium so that no country is winning the trade war:
  - Mean welfare loss: -2.9%; median Nash tariff: 63.4%
- Trade negotiations yield significant welfare gains of which most have been reaped in past trade rounds:
  - Mean welfare gain: relative to Nash tariffs: 3.6%; relative to factual tariffs: 0.5%

Contribution

- I am unaware of any quantitative analysis of noncooperative and cooperative trade policy which is comparable in terms of its scope
  - This is the first quantitative framework which nests traditional, new trade, and political economy motives for protection
  - There is no precedent for estimating noncooperative and cooperative tariffs at the industry-level for the major players in recent GATT/WTO negotiations
- The surprising lack of comparable work is probably rooted in long-binding methodological and computational constraints
  - The calibration of general equilibrium trade models has only been widely embraced quite recently following the seminal work of Eaton and Kortum (2002)
  - The calculation of disaggregated noncooperative and cooperative tariffs is very demanding computationally and was simply not feasible without present-day algorithms and computers

Immediate predecessors

- Perroni and Whalley (2000) provide estimates of noncooperative tariffs in an Armington model which features only traditional terms-of-trade effects
- Ossa (2011) provides such estimates in a Krugman (1980) model which features only new trade production relocation effects
- Both contributions allow trade policy to operate only at the most aggregate level so that a single tariff is assumed to apply against all imports from a given country
- Broda et al (2008) provide detailed estimates of the inverse export supply elasticities faced by many non-WTO member countries to test the optimal tariff formula

Other related work

- The motives for protection are taken from the theoretical trade policy literature including Johnson (1953-54), Venables (1987), and Grossman and Helpman (1994)
- The analysis of trade negotiations builds on a line of research synthesized by Bagwell and Staiger (2002)
- My calibration technique is similar to the one used in recent quantitative work using the Eaton and Kortum (2002) model such as Caliendo and Parro (2011)

Data

- I focus on 7 regions and 33 industries in 2007. My main datasource is the most recent Global Trade Analysis Project (GTAP) database
- The regions comprise the main players in GATT/WTO negotiations. The industries span the agricultural and manufacturing sectors
- In addition, I use the NBER-UN trade data for the time period 1994-2008 for my estimation of the demand elasticities
- Also, I draw on the International Trade Centre's Market Access Map tariff data as well as the United Nation's TRAINS tariff data for my calibration of the political economy weights

Elasticity estimation

- I estimate the demand elasticities using the method of Feenstra (1994) which exploits variation in demand and supply shocks across countries
- I use the NBER-UN trade data because I need a panel of import prices and quantities which is not available from the GTAP database
- Following my theory, I do not allow for variation in demand elasticities across countries and run a pooled regression using my 6 main regions
- The variation in my elasticity estimates appears plausible and their mean is broadly in line with previous findings in the literature

Elasticity estimation

TABLE 1: Elasticity estimates

Wheat	10.07	Plant-based fibers	2.80
Rice	7.01	Wool, etc	2.76
Dairy	5.89	Motor vehicles, etc	2.75
Wearing apparel	5.39	Metal products	2.70
Other metals	4.47	Sugar	2.69
Vegetable oils, etc	4.03	Other food products	2.62
Bovine meat products	3.89	Paper products, etc.	2.56
Leather products	3.67	Other crops	2.53
Ferrous metals	3.67	Electronic equipment	2.49
Other manufactures	3.53	Other mineral products	2.47
Other cereal grains	3.32	Other machinery, etc.	2.46
Oil seeds	3.21	Vegetables, etc.	2.42
Other meat products	3.20	Chemical products, etc.	2.34
Beverages, etc.	2.92	Wood products	2.32
Bovine cattle, etc.	2.91	Forestry	2.20
Textiles	2.87	Other animal products	1.91
Other transport equipment	2.84	Mean	3.42

Setup

- Love-of-variety preferences

$$U_j = \prod_s \left(\sum_i \int_0^{M_{is}} x_{ijs} \left(\nu_{is} \right)^{\frac{\sigma_s - 1}{\sigma_s}} d\nu_{is} \right)^{\frac{\sigma_s}{\sigma_s - 1} \mu_{js}}$$

- Comparative advantage technology

$$l_{is} = \sum_j \frac{\theta_{ijs} x_{ijs}}{\varphi_{is}}$$

- Politically motivated governments

$$G_j = \sum_s \lambda_{js} W_{js}$$

$$W_{js} = \frac{w_j L_{js} + \pi_{js} + \frac{L_{js}}{L_j} TR_j}{P_j}$$

Equilibrium conditions in levels

Definition

For given tariffs, an equilibrium is a set of $\{w_i, X_i, P_{is}, \pi_{is}\}$ such that

$$\pi_{is} = \frac{1}{\sigma_s} \sum_j M_{is} \tau_{ijs}^{-\sigma_s} \left(\frac{\sigma_s}{\sigma_s - 1} \frac{\theta_{ijs}}{\varphi_{is}} \frac{w_i}{P_{js}} \right)^{1-\sigma_s} \mu_{sj} X_j$$

$$w_i L_i = \sum_s \pi_{is} (\sigma_s - 1)$$

$$P_{js} = \left(\sum_i M_{is} \left(\frac{\sigma_s}{\sigma_s - 1} \frac{w_i \theta_{ijs} \tau_{ijs}}{\varphi_{is}} \right)^{1-\sigma_s} \right)^{\frac{1}{1-\sigma_s}}$$

$$X_j = w_j L_j + \sum_i \sum_s t_{ijs} M_{is} \left(\frac{\sigma_s}{\sigma_s - 1} \frac{\theta_{ijs}}{\varphi_{is}} \frac{w_i}{P_{js}} \right)^{1-\sigma_s} \tau_{ijs}^{-\sigma_s} \mu_{sj} X_j + \sum_s \pi_{js}$$

This is in terms of many unknown parameters!

Equilibrium conditions in changes

Definition

For given tariff changes, an equilibrium is a set of $\left\{\widehat{w}_i, \widehat{X}_i, \widehat{P}_{is}, \widehat{\pi}_{is}\right\}$ such that

$$\widehat{\pi}_{is}\left(\widehat{w}_i\right)^{\sigma_s-1} = \sum_j \frac{T_{ijs}}{\sum_n T_{ins}}\left(\widehat{\tau}_{ijs}\right)^{-\sigma_s}\left(\widehat{P}_{js}\right)^{\sigma_s-1}\widehat{X}_j$$

$$\widehat{w}_i = \sum_s \frac{\frac{\sigma_s-1}{\sigma_s}\sum_j T_{ijs}}{\sum_t \frac{\sigma_t-1}{\sigma_t}\sum_n T_{int}}\widehat{\pi}_{is}$$

$$\widehat{P}_{js} = \left(\sum_i \frac{\tau_{ijs}T_{ijs}}{\sum_m \tau_{mjs}T_{mjs}}\left(\widehat{w}_i\widehat{\tau}_{ijs}\right)^{1-\sigma_s}\right)^{\frac{1}{1-\sigma_s}}$$

$$\widehat{X}_j = \frac{w_j L_j}{X_j}\widehat{w}_j + \sum_i\sum_s \frac{t_{ijs}T_{ijs}}{X_j}\widehat{t}_{ijs}\left(\widehat{w}_i\right)^{1-\sigma_s}\left(\widehat{P}_{js}\right)^{\sigma_{s-1}}\left(\widehat{\tau}_{ijs}\right)^{-\sigma_s}\widehat{X}_j + \sum_s \frac{\pi_{js}}{X_j}\widehat{\pi}_{js}$$

This is in terms of σ_s and observable tariffs and trade flows only!

Details

Eliminating trade imbalances

- The standard way of dealing with trade imbalances is to introduce them as parameters into the budget constraints
- There are two important problems with this approach which have been largely unnoticed in the literature:
  - It leads to extreme general equilibrium adjustments in response to high tariffs and cannot hold in the limit
  - Even though changes in nominal transfers are zero, changes in real transfers are not, and depend on the choice of numeraire
- To circumvent these problems, I first purge my data of trade imbalances using my model and then analyze trade policy using the purged dataset

Details

Illustration of general equilibrium effects

TABLE 2: Effects of 50 percentage point increase in US tariff

	General equilibrium effects		
	Δ US wage	Δ US production (protected)	Δ US production (other)
Chem.	1.45%	5.73%	-1.40%
Appar.	0.67%	33.35%	-0.97%

	Welfare effects		
	Δ US welfare	Terms-of-trade effect	Profit shifting effect
Chem.	0.17%	0.34%	0.12%
Appar.	-0.14%	0.16%	-0.15%

Notes: Chemicals have a relatively low elasticity of substitution of 2.34 while apparel has a relatively high elasticity of substitution of 5.39.

Welfare effects of tariff changes

- The implied welfare effects $\widehat{W}_j = \dfrac{\widehat{X}_j}{\Pi_s \left(\widehat{P}_{js}\right)^{\mu_{js}}}$ can be decomposed into traditional and new trade components:
  - $\dfrac{\Delta W_j}{W_j} \approx \sum_i \sum_s \dfrac{T_{ijs}}{X_j} \left(\dfrac{\Delta p_{js}}{p_{js}} - \dfrac{\Delta p_{is}}{p_{is}} \right)$: *Terms-of-trade effect*
  - $+ \sum_s \dfrac{\pi_{js}}{X_j} \left(\dfrac{\Delta \pi_{js}}{\pi_{js}} - \dfrac{\Delta p_{js}}{p_{js}} \right)$: *Profit shifting effect*
  - $+ \sum_i \sum_s \dfrac{t_{ijs} T_{ijs}}{X_j} \left(\dfrac{\Delta T_{ijs}}{T_{ijs}} - \dfrac{\Delta p_{is}}{p_{is}} \right)$: *Trade volume effect*

Illustration of welfare effects

TABLE 2: Effects of 50 percentage point increase in US tariff

	General equilibrium effects		
	Δ US wage	Δ US production (protected)	Δ US production (other)
Chem.	1.45%	5.73%	-1.40%
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	Welfare effects		
	Δ US welfare	Terms-of-trade effect	Profit shifting effect
Chem.	0.17%	0.34%	0.12%
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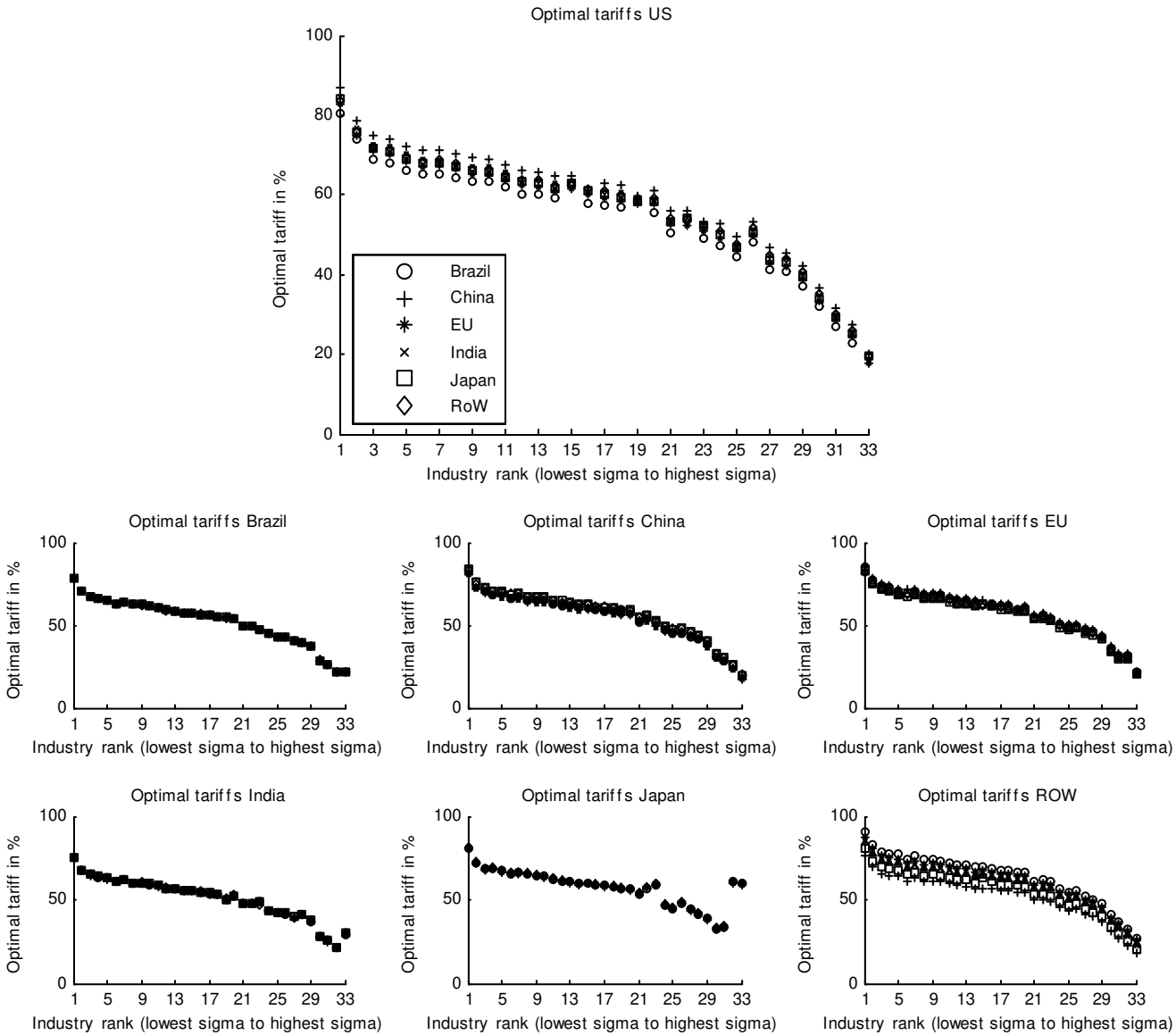
Optimal tariffs - without lobbying



Optimal tariffs - without lobbying

TABLE 3a: Optimal tariffs without lobbying

	Δ gvt. welfare		Δ welfare		Δ wage		Δ profits		opt. tariff
	own	other	own	other	own	other	own	other	median
Brazil	1.1%	-0.1%	1.1%	-0.1%	18.2%	-3.0%	0.8%	-0.0%	56.1%
China	1.8%	-0.6%	1.8%	-0.6%	17.6%	-2.9%	0.5%	-0.1%	59.3%
EU	1.9%	-1.0%	1.9%	-1.0%	22.5%	-3.7%	0.1%	-0.2%	61.3%
India	1.7%	-0.1%	1.7%	-0.1%	8.7%	-1.5%	2.7%	-0.1%	54.0%
Japan	4.0%	-0.3%	4.0%	-0.3%	18.6%	-3.1%	1.7%	-0.1%	59.6%
RoW	2.9%	-1.7%	2.9%	-1.7%	19.0%	-3.2%	1.1%	-0.6%	61.5%
US	2.3%	-0.9%	2.3%	-0.9%	23.8%	-4.0%	0.6%	-0.1%	60.3%
Mean	2.2%	-0.7%	2.2%	-0.7%	18.3%	-3.1%	1.1%	-0.2%	58.9%

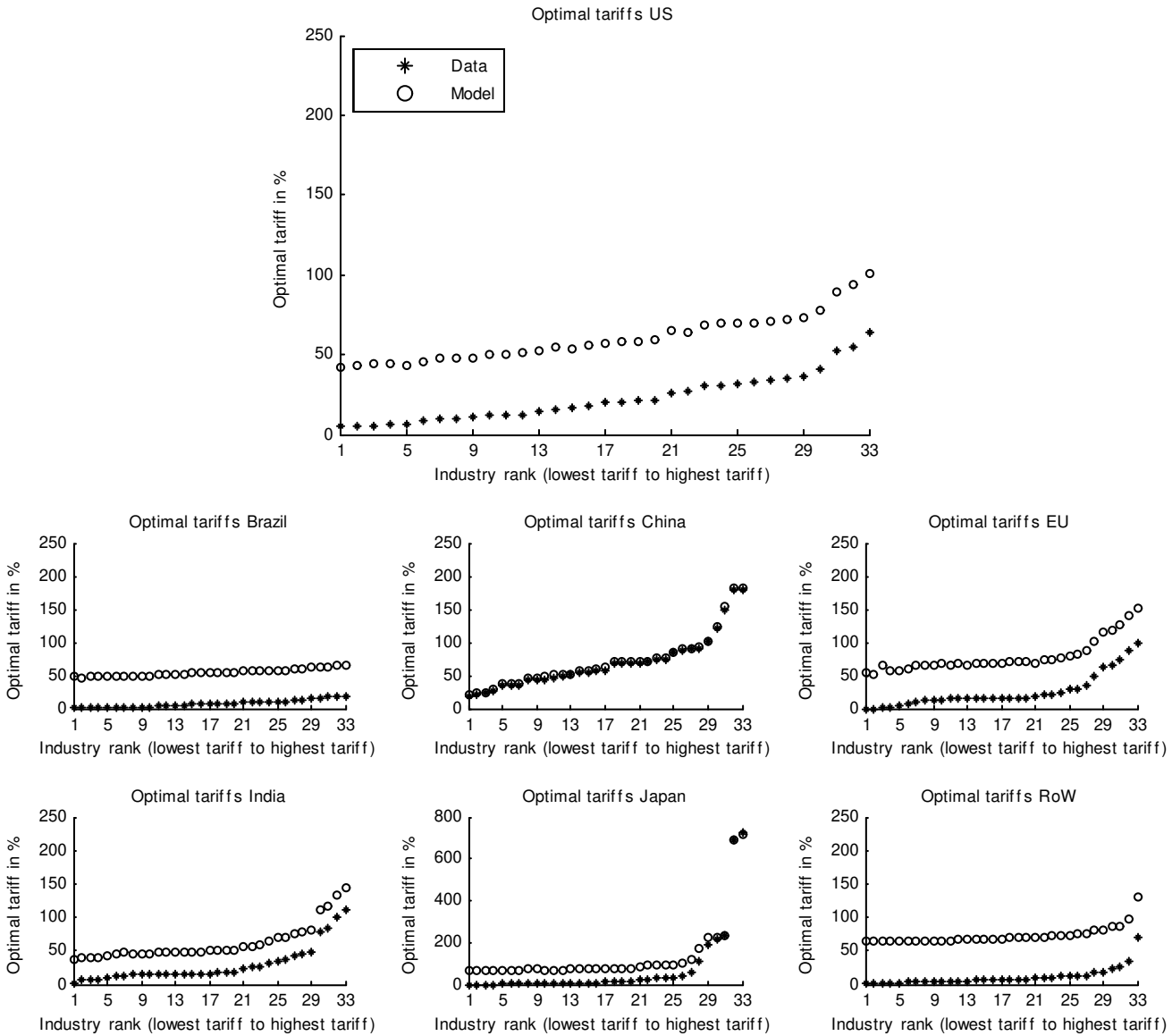
Calibrating the political economy weights

- Political economy forces provide a plausible explanation for the cross-industry variation in factual tariffs
- A natural approach to identifying λ_{is} would therefore be to match the distribution of factual tariffs
- However, factual tariffs are the result of trade negotiations so that their relationship to optimal tariffs is far from clear
- I therefore calibrate λ_{is} to measures of noncooperative tariffs if available in the MAcMap or TRAINS database

Measures of noncooperative tariffs

- Direct measures of noncooperative tariffs are available for China, Japan, and the US from MAcMap and for the EU from TRAINS
- Brazil and India's factual tariffs might reflect their noncooperative tariffs to some extent
- Naturally, these measures of noncooperative tariffs have to be taken with a large grain of salt
- However, all aggregate results are quite robust to the choice of political economy weights

Optimal tariffs - with lobbying



Politically most influential industries

TABLE: Top-5 most influential industries

	λ_{BRA}	λ_{CHN}	λ_{EU}	λ_{IND}	λ_{JPN}	λ_{US}
1	Apparel	Wheat	Wheat	Wheat	Wheat	Apparel
2	Wheat	Rice	Dairy	Tobacco	Rice	Dairy
3	Dairy	Apparel	Rice	Oils	Oil seeds	Textiles
4	Rice	Tobacco	Beef	Rice	Cereal	Tobacco
5	Leather	Dairy	Tobacco	Sugar	Dairy	Wheat

Optimal tariffs - with lobbying

TABLE 3b: Optimal tariffs with lobbying

	Δ gvt. welfare		Δ welfare		Δ wage		Δ profits		opt. tariff
	own	other	own	other	own	other	own	other	median
Brazil	0.9%	-0.1%	1.0%	-0.1%	18.1%	-3.0%	0.3%	-0.0%	54.2%
China	1.5%	-0.4%	1.5%	-0.5%	13.3%	-2.2%	0.1%	-0.0%	60.7%
EU	2.2%	-1.2%	1.7%	-1.1%	27.0%	-4.5%	-0.9%	0.1%	69.0%
India	0.5%	-0.0%	0.7%	-0.0%	11.4%	-1.9%	0.6%	-0.0%	49.9%
Japan	2.6%	-0.4%	1.0%	-0.4%	30.0%	-5.0%	-1.4%	0.1%	77.5%
RoW	2.9%	-1.7%	2.6%	-1.8%	21.9%	-3.7%	-0.1%	-0.2%	68.9%
US	2.5%	-0.9%	2.1%	-0.9%	26.4%	-4.4%	-0.2%	0.0%	56.4%
Mean	1.9%	-0.7%	1.5%	-0.7%	21.2%	-3.5%	-0.2%	0.0%	62.4%

TABLE 3a: Optimal tariffs without lobbying

Mean	2.2%	-0.7%	2.2%	-0.7%	18.3%	-3.1%	1.1%	-0.2%	58.9%

Optimal tariffs - sensitivity

TABLE 3c: Sensitivity of optimal tariffs w.r.t. σ_s

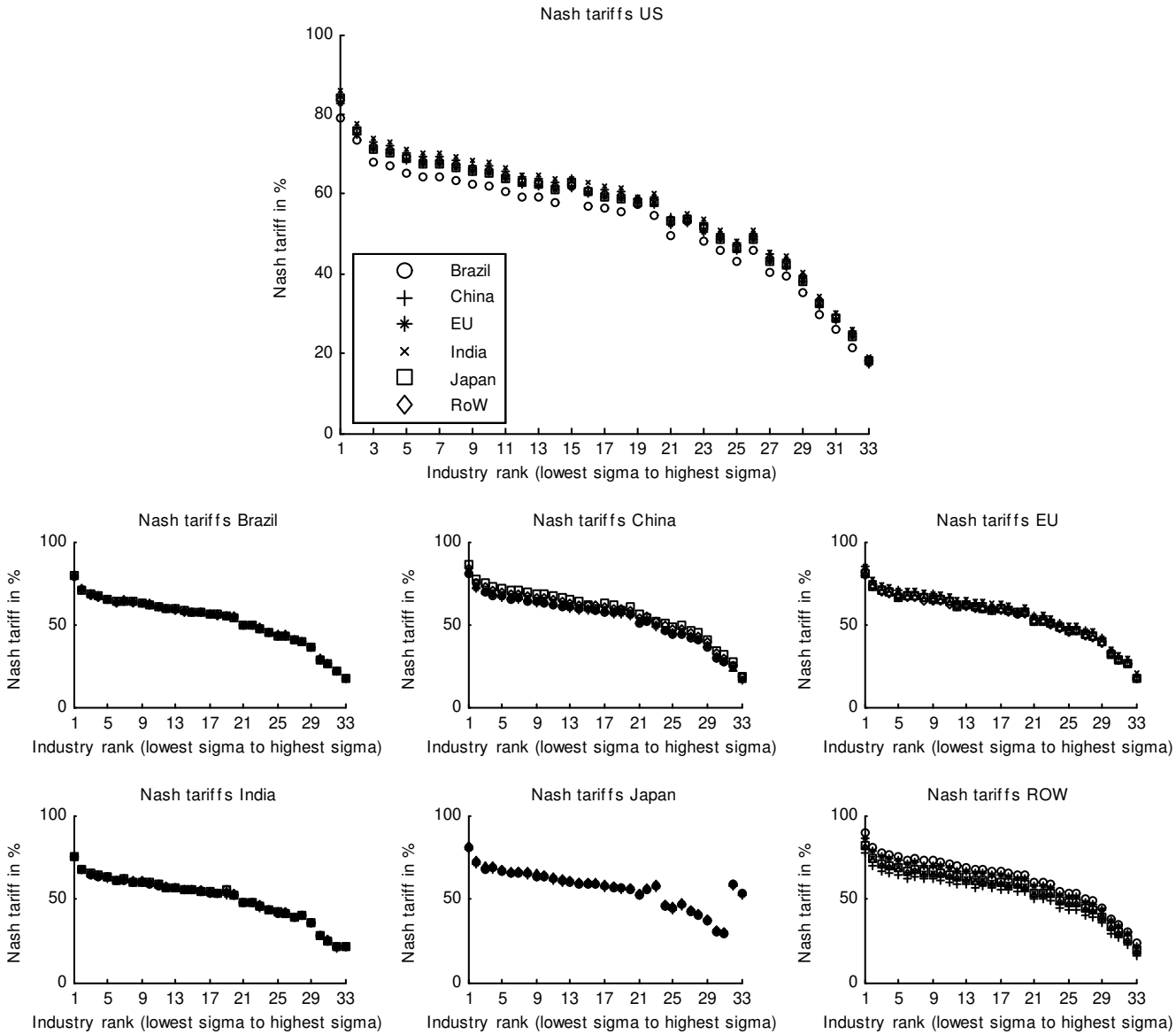
Without lobbying (all values are means)

σ	Δ gvt. welfare		Δ welfare		Δ wage		Δ profits		opt. tariff
mean	own	other	own	other	own	other	own	other	median
3.5	2.2%	-0.6%	2.2%	-0.6%	17.6%	-2.9%	1.1%	-0.2%	56.8%
5.0	1.7%	-0.4%	1.7%	-0.4%	9.1%	-1.5%	1.1%	-0.2%	34.3%
6.5	1.5%	-0.2%	1.5%	-0.2%	5.4%	-0.9%	1.1%	-0.2%	24.6%

With lobbying (all values are means)

σ	Δ gvt. welfare		Δ welfare		Δ wage		Δ profits		opt. tariff
mean	own	other	own	other	own	other	own	other	median
3.5	1.8%	-0.6%	1.5%	-0.6%	20.2%	-3.4%	-0.2%	0.0%	60.1%
5.0	1.2%	-0.4%	0.9%	-0.4%	10.5%	-1.7%	-0.2%	0.0%	35.5%
6.5	1.1%	-0.3%	0.7%	-0.3%	6.5%	-1.1%	-0.2%	0.0%	25.6%

Trade wars - without lobbying

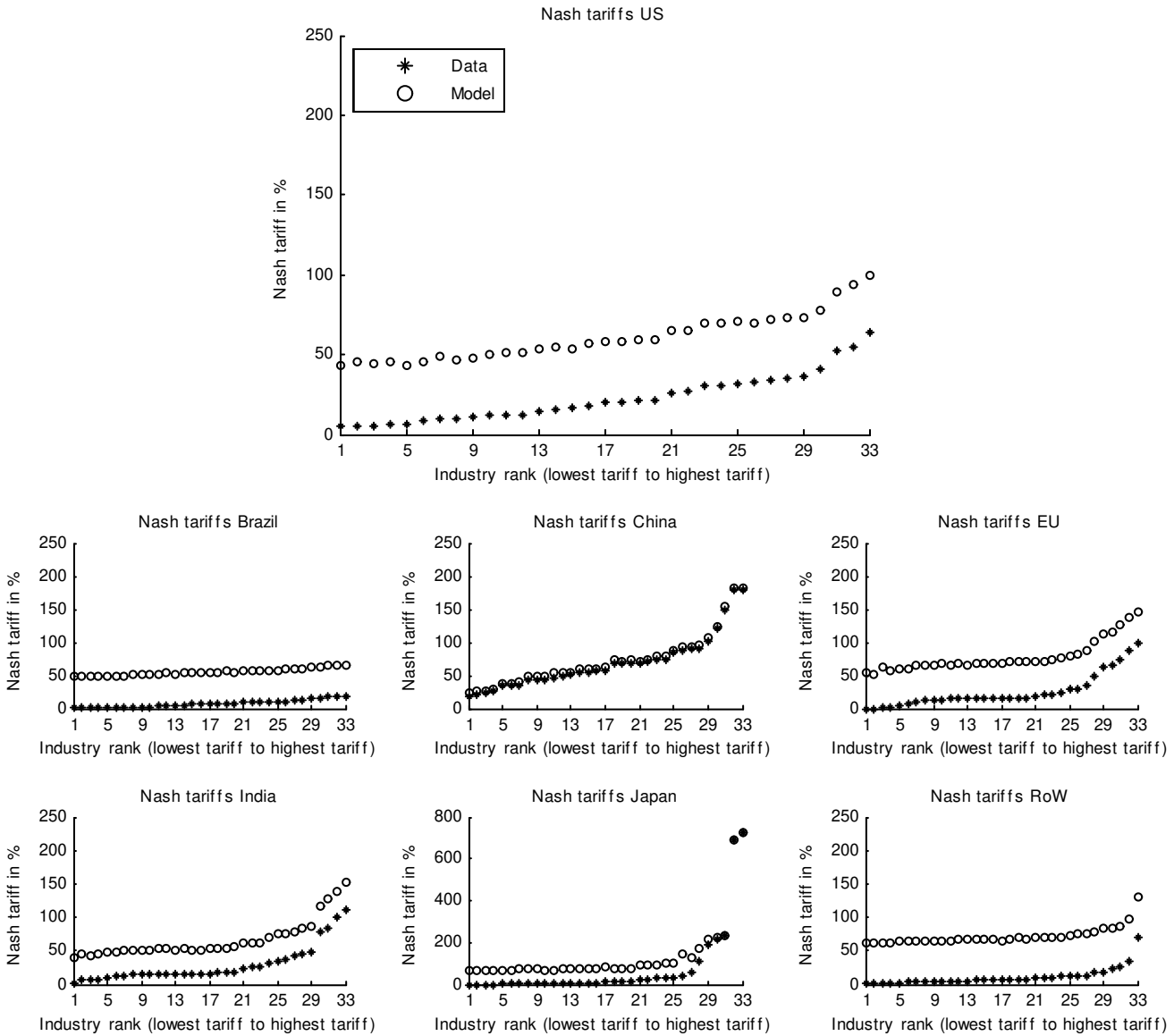


Trade wars - without lobbying

TABLE 5a: Nash tariffs without lobbying

	Δ gvt. welfare	Δ welfare	Δ wage	Δ profits	Nash tariff
Brazil	-1.9%	-1.9%	1.3%	0.4%	56.4%
China	-2.2%	-2.2%	0.5%	-0.2%	58.6%
EU	-2.6%	-2.6%	2.7%	-0.9%	59.1%
India	-2.2%	-2.2%	-9.3%	1.9%	54.5%
Japan	-0.8%	-0.8%	-0.6%	0.7%	58.5%
RoW	-5.0%	-5.0%	-0.8%	-0.6%	59.7%
US	-2.2%	-2.2%	6.3%	-0.3%	59.6%
Mean	-2.4%	-2.4%	0.0%	0.2%	58.1%

Trade wars - with lobbying



Trade wars - with lobbying

TABLE 5b: Nash tariffs with lobbying

	Δ gvt. welfare	Δ welfare	Δ wage	Δ profits	Nash tariff
Brazil	-2.7%	-2.5%	-4.6%	0.5%	54.7%
China	-3.4%	-2.9%	-7.1%	0.3%	62.9%
EU	-2.2%	-2.7%	5.6%	-1.2%	69.4%
India	-3.6%	-3.3%	-10.5%	0.8%	54.1%
Japan	-1.0%	-2.8%	11.4%	-1.7%	77.6%
RoW	-5.3%	-5.6%	-1.3%	-0.1%	68.5%
US	-2.0%	-2.4%	6.5%	-0.2%	56.6%
Mean	-2.9%	-3.2%	0.0%	-0.2%	63.4%

TABLE 5a: Nash tariffs without lobbying

Mean	-2.4%	-2.4%	0.0%	0.2%	58.1%

Trade wars - sensitivity

TABLE 5c: Sensitivity of Nash tariffs w.r.t. σ_s

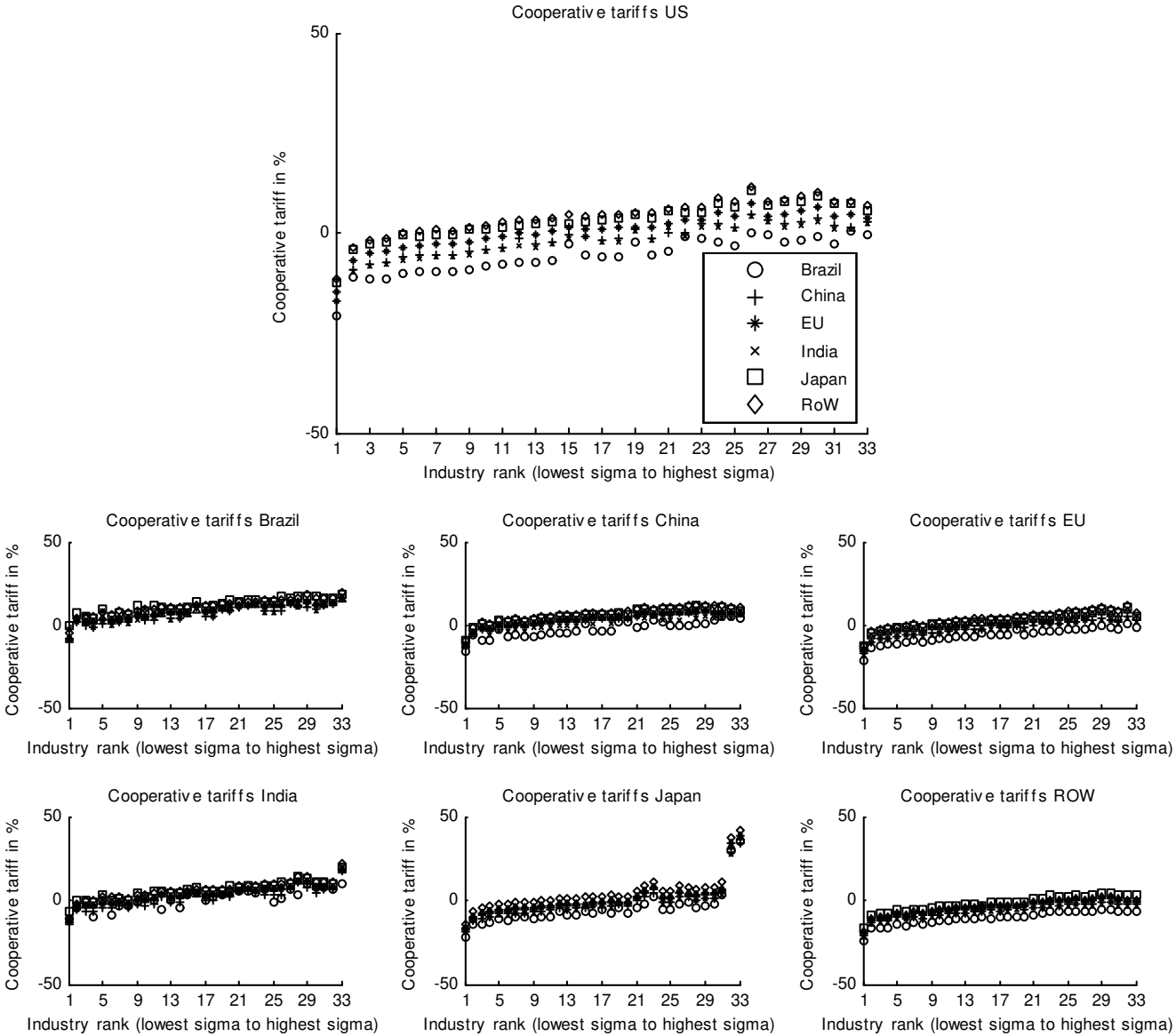
Without lobbying (all values are means)

σ_{mean}	Δ gvt. welfare	Δ welfare	Δ wage	Δ profits	Nash tariff
3.5	-2.3%	-2.3%	0.0%	0.2%	56.0%
5.0	-1.0%	-1.0%	0.0%	0.3%	34.4%
6.5	-0.3%	-0.3%	0.0%	0.2%	25.4%

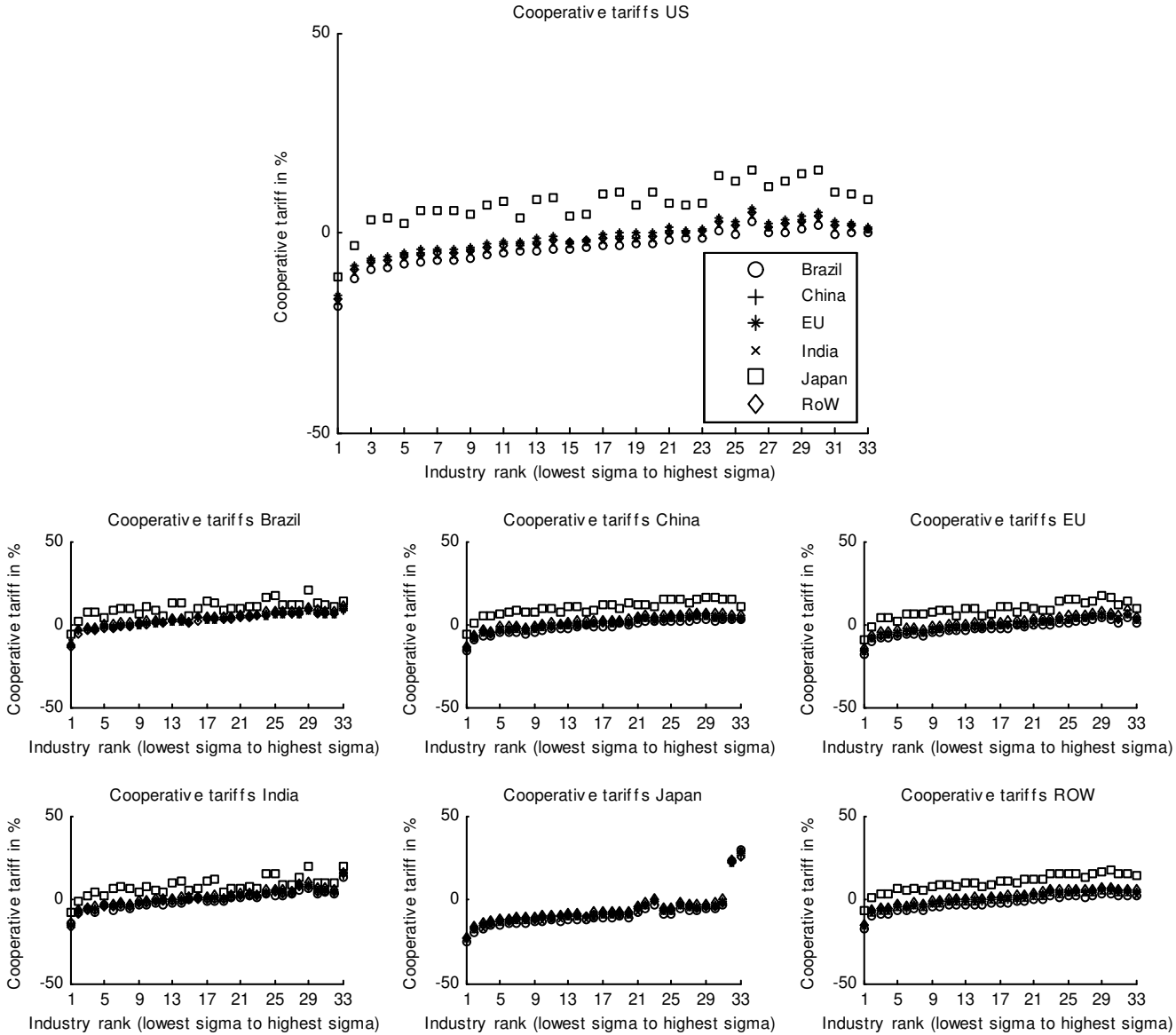
With lobbying (all values are means)

σ_{mean}	Δ gvt. welfare	Δ welfare	Δ wage	Δ profits	Nash tariff
3.5	-2.8%	-3.0%	0.0%	-0.2%	61.2%
5.0	-1.5%	-1.7%	0.0%	-0.1%	36.2%
6.5	-0.8%	-1.1%	0.0%	-0.1%	26.4%

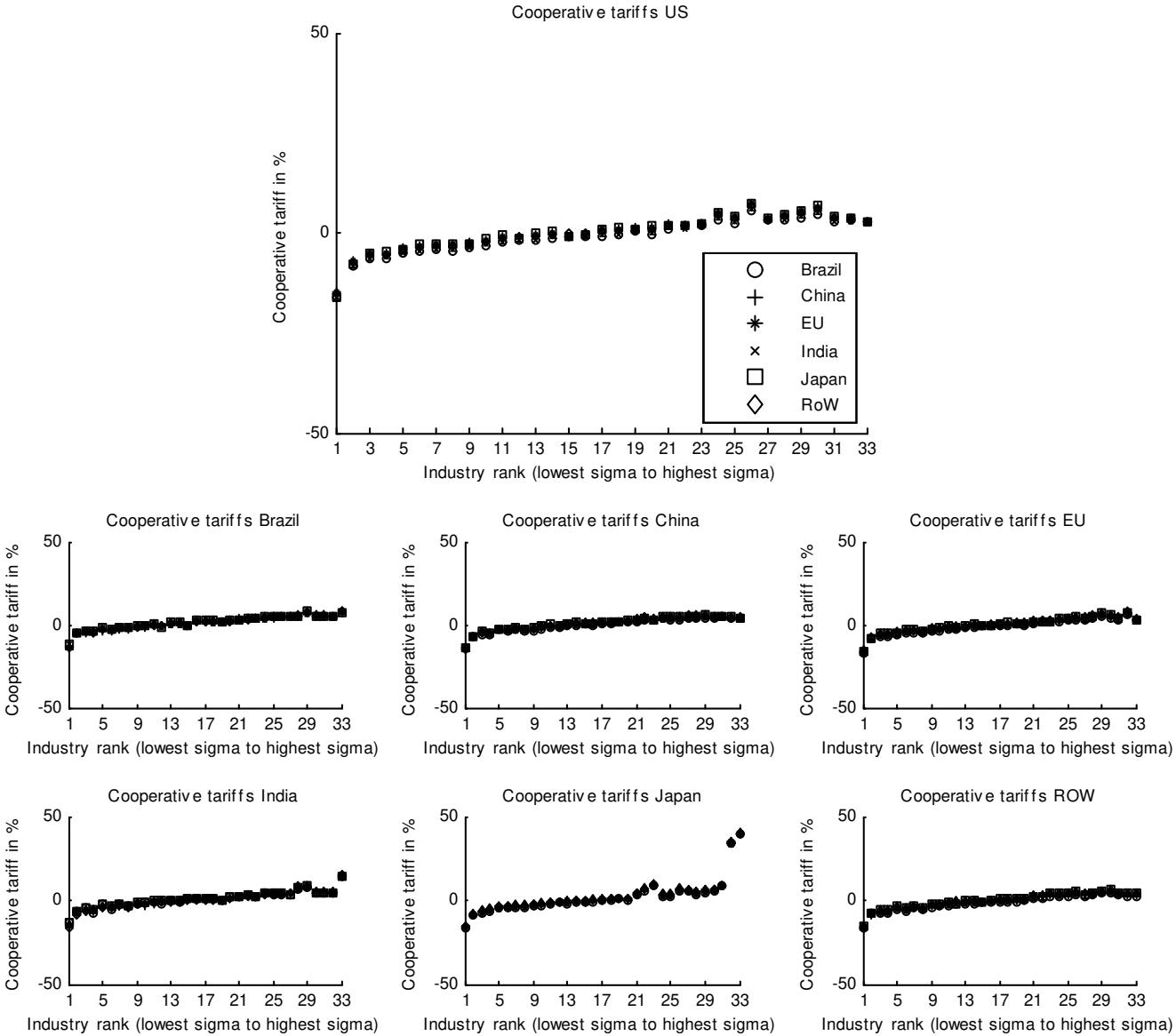
Trade talks - without lobbying (relative to Nash tariffs)



Trade talks - without lobbying (relative to factual tariffs)



Trade talks - without lobbying (relative to free trade)



Trade talks - without lobbying

TABLE 7a: Cooperative tariffs without lobbying

	Δ gvt. welfare			Δ welfare			Δ wage			Δ profits		
	Nash	Fact.	Free	Nash	Fact.	Free	Nash	Fact.	Free	Nash	Fact.	Free
Brazil	3.4%	0.5%	0.03%	3.4%	0.5%	0.03%	9.2%	6.1%	0.1%	-0.7%	-0.7%	0.0%
China	3.4%	0.5%	0.03%	3.4%	0.5%	0.03%	0.0%	0.2%	-0.2%	-0.8%	-0.9%	0.2%
EU	3.4%	0.5%	0.03%	3.4%	0.5%	0.03%	-2.1%	2.7%	0.1%	1.0%	0.3%	0.0%
India	3.4%	0.5%	0.03%	3.4%	0.5%	0.03%	5.8%	-4.0%	-0.1%	-0.9%	1.0%	0.2%
Japan	3.4%	0.5%	0.03%	3.4%	0.5%	0.03%	-2.7%	-9.4%	0.6%	1.4%	1.8%	-0.2%
RoW	3.4%	0.5%	0.03%	3.4%	0.5%	0.03%	-6.0%	1.8%	-0.2%	0.6%	-0.2%	0.3%
US	3.4%	0.5%	0.03%	3.4%	0.5%	0.03%	-4.2%	2.8%	-0.3%	0.4%	0.3%	0.2%
Mean	3.4%	0.5%	0.03%	3.4%	0.5%	0.03%	0.0%	0.0%	0.0%	0.1%	0.2%	0.1%

Trade talks - with lobbying

TABLE 7b: Cooperative tariffs with lobbying

	Δ gvt. welfare			Δ welfare			Δ wage			Δ profits		
	Nash	Fact.	Free	Nash	Fact.	Free	Nash	Fact.	Free	Nash	Fact.	Free
Brazil	3.6%	0.5%	0.2%	3.5%	0.5%	0.28%	10.7%	3.3%	1.4%	-0.7%	-0.1%	0.6%
China	3.6%	0.5%	0.2%	1.0%	-1.6%	-1.25%	-4.7%	-8.0%	-3.1%	-2.3%	-2.1%	-1.4%
EU	3.6%	0.5%	0.2%	4.0%	0.3%	-0.01%	-2.7%	0.9%	0.8%	1.4%	0.0%	-0.1%
India	3.6%	0.5%	0.2%	3.6%	0.8%	-0.86%	5.7%	0.6%	-0.7%	-0.6%	0.2%	-0.7%
Japan	3.6%	0.5%	0.2%	4.9%	0.5%	-0.44%	-0.8%	1.5%	1.0%	1.7%	0.5%	-0.5%
RoW	3.6%	0.5%	0.2%	4.2%	0.7%	0.28%	-4.7%	1.1%	1.0%	0.4%	0.3%	0.5%
US	3.6%	0.5%	0.2%	4.1%	0.6%	0.15%	-3.5%	0.6%	-0.4%	1.0%	1.0%	1.0%
Mean	3.6%	0.5%	0.2%	3.6%	0.3%	-0.27%	0.0%	0.0%	0.0%	0.1%	0.0%	-0.1%

TABLE 7a: Cooperative tariffs without lobbying

Mean	3.4%	0.5%	0.03%	3.4%	0.5%	0.03%	0.0%	0.0%	0.0%	0.1%	0.2%	0.1%

Trade talks - sensitivity

TABLE 7c: Sensitivity of cooperative tariffs w.r.t. σ_s

Without lobbying (all values are means)

σ	Δ gvt. welfare			Δ welfare			Δ wage			Δ profits		
mean	Nash	Fact.	Free	Nash	Fact.	Free	Nash	Fact.	Free	Nash	Fact.	Free
3.5	3.3%	0.5%	0.03%	3.3%	0.5%	0.03%	0.0%	0.0%	0.0%	0.1%	0.2%	0.1%
5.0	2.2%	0.8%	0.01%	2.2%	0.8%	0.01%	0.0%	0.0%	0.0%	-0.1%	0.1%	0.1%
6.5	1.7%	1.1%	0.01%	1.7%	1.1%	0.01%	0.0%	0.0%	0.0%	-0.2%	0.0%	0.1%

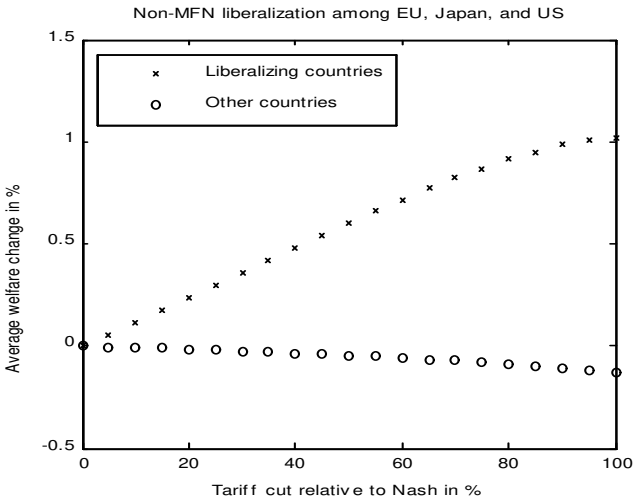
With lobbying (all values are means)

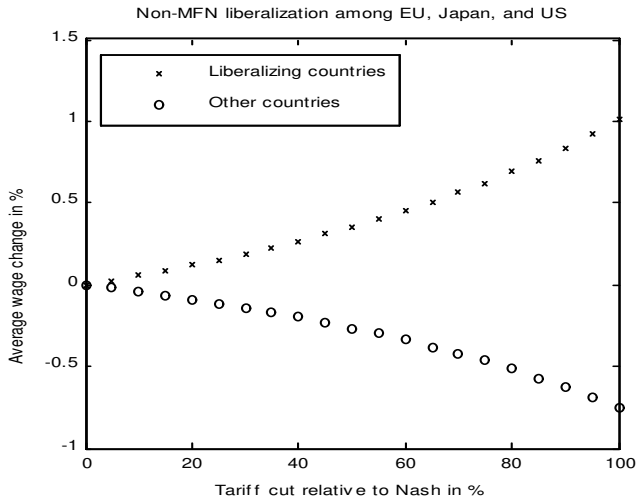
σ	Δ gvt. welfare			Δ welfare			Δ wage			Δ profits		
mean	Nash	Fact.	Free	Nash	Fact.	Free	Nash	Fact.	Free	Nash	Fact.	Free
3.5	3.5%	0.5%	0.2%	3.5%	0.3%	-0.26%	0.0%	0.0%	0.0%	0.1%	0.0%	-0.1%
5.0	2.3%	0.7%	0.3%	2.2%	0.4%	-0.29%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
6.5	1.8%	1.0%	0.4%	1.7%	0.6%	-0.33%	0.0%	0.0%	0.0%	0.1%	0.0%	0.2%

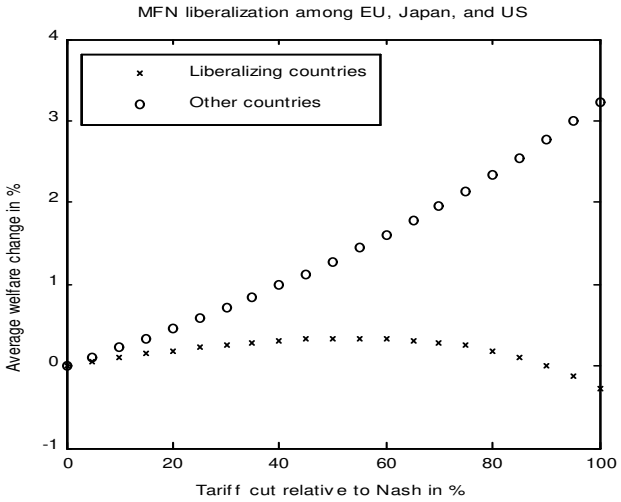
Trade talks - MFN

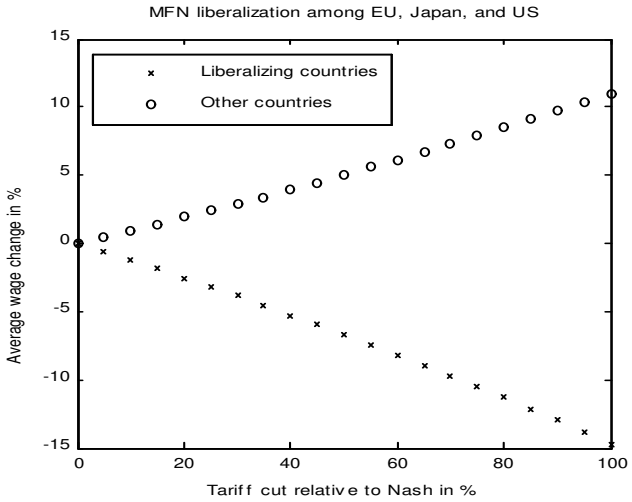
- In the paper, I provide a detailed discussion of the effects of imposing the most-favored nation (MFN) principle
- One finding is that MFN by itself is hardly effective in pushing countries towards the efficiency frontier
- Another finding is that MFN protects "outsider" countries from liberalization among "insider countries"
- However, it also makes "insider" liberalizations much less attractive by more than neutralizing their adverse external effects

Trade talks - MFN









Conclusion

- I proposed a unified framework for the quantitative analysis of noncooperative and cooperative trade policy
- I used this framework to provide a first comprehensive quantitative analysis of noncooperative and cooperative trade policy
- The interpretation of my results depends on whether the framework is taken as a maintained or tested hypothesis
- Given the near-absence of quantitative analyses in the existing literature, there is much scope for future work

Proof.

$$P_{js} = \left(\sum_i M_{is} \left(\frac{\sigma_s}{\sigma_s - 1} \frac{w_i \theta_{ijs} \tau_{ijs}}{\varphi_{is}} \right)^{1-\sigma_s} \right)^{\frac{1}{1-\sigma_s}}$$

$$\frac{P'_{js}}{P_{js}} = \left(\sum_i \frac{\tau_{ijs} M_{is} \left(\frac{\sigma_s}{\sigma_s - 1} \frac{\theta_{ijs}}{\varphi_{is}} \frac{w_i}{P_{js}} \right)^{1-\sigma_s} \tau_{ijs}^{-\sigma} \mu_{sj} X_j}{\sum_m \tau_{mjs} M_{ms} \left(\frac{\sigma_s}{\sigma_s - 1} \frac{\theta_{mjs}}{\varphi_{ms}} \frac{w_m}{P_{js}} \right)^{1-\sigma_s} \tau_{mjs}^{-\sigma} \mu_{sj} X_j} \left(\frac{w'_i}{w_i} \frac{\tau'_{ijs}}{\tau_{ijs}} \right)^{1-\sigma_s} \right)^{\frac{1}{1-\sigma_s}}$$

$$T_{ijs} = M_{is} \left(\frac{\sigma_s}{\sigma_s - 1} \frac{\theta_{ijs}}{\varphi_{is}} \frac{w_i}{P_{js}} \right)^{1-\sigma_s} \tau_{ijs}^{-\sigma} \mu_{sj} X_j$$

$$\widehat{P}_{js} = \left(\sum_i \frac{\tau_{ijs} T_{ijs}}{\sum_m \tau_{mjs} T_{mjs}} \left(\widehat{w}_i \widehat{\tau}_{ijs} \right)^{1-\sigma_s} \right)^{\frac{1}{1-\sigma_s}}$$

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Eliminating trade imbalances

Definition

For given tariffs, an equilibrium is a set of $\{w_i, X_i, P_{is}, \pi_{is}\}$ such that

$$\pi_{is} = \frac{1}{\sigma_s} \sum_j M_{is} \tau_{ijs}^{-\sigma_s} \left(\frac{\sigma_s}{\sigma_s - 1} \frac{\theta_{ijs}}{\varphi_{is}} \frac{w_i}{P_{js}} \right)^{1-\sigma_s} \mu_{sj} X_j$$

$$w_i L_i = \sum_s \pi_{is} (\sigma_s - 1)$$

$$P_{js} = \left(\sum_i M_{is} \left(\frac{\sigma_s}{\sigma_s - 1} \frac{w_i \theta_{ijs} \tau_{ijs}}{\varphi_{is}} \right)^{1-\sigma_s} \right)^{\frac{1}{1-\sigma_s}}$$

$$X_j = w_j L_j + \sum_i \sum_s t_{ijs} M_{is} \left(\frac{\sigma_s}{\sigma_s - 1} \frac{\theta_{ijs}}{\varphi_{is}} \frac{w_i}{P_{js}} \right)^{1-\sigma_s} \tau_{ijs}^{-\sigma_s} \mu_{sj} X_j + \sum_s \pi_{js} - N X_j$$

The only difference is the additional parameter NX_j.

Definition

For given tariff changes, an equilibrium is a set of $\left\{\widehat{w}_i, \widehat{X}_i, \widehat{P}_{is}, \widehat{\pi}_{is}\right\}$ such that

$$\widehat{\pi}_{is}\left(\widehat{w}_i\right)^{\sigma_s-1} = \sum_j \frac{T_{ijs}}{\sum_n T_{ins}}\left(\widehat{\tau}_{ijs}\right)^{-\sigma_s}\left(\widehat{P}_{js}\right)^{\sigma_s-1}\widehat{X}_j$$

$$\widehat{w}_i = \sum_s \frac{\frac{\sigma_s-1}{\sigma_s}\sum_j T_{ijs}}{\sum_t \frac{\sigma_t-1}{\sigma_t}\sum_n T_{int}}\widehat{\pi}_{is}$$

$$\widehat{P}_{js} = \left(\sum_i \frac{\tau_{ijs}T_{ijs}}{\sum_m \tau_{mjs}T_{mjs}}\left(\widehat{w}_i\widehat{\tau}_{ijs}\right)^{1-\sigma_s}\right)^{\frac{1}{1-\sigma_s}}$$

$$\widehat{X}_j = \frac{w_j L_j}{X_j}\widehat{w}_j + \sum_i\sum_s \frac{t_{ijs}T_{ijs}}{X_j}\widehat{t}_{ijs}\left(\widehat{w}_i\right)^{1-\sigma_s}\left(\widehat{P}_{js}\right)^{\sigma_{s-1}}\left(\widehat{\tau}_{ijs}\right)^{-\sigma_s}\widehat{X}_j + \sum_s \frac{\pi_{js}}{X_j}\widehat{\pi}_{js} - \frac{NX_j}{X_j}\widehat{NX}_j$$

I eliminate trade imbalances by setting $\widehat{t}_{ijs} = \widehat{\tau}_{ijs} = 1$ and $\widehat{NX}_j = 0$.

Eliminating trade imbalances

TABLE 0: Eliminating aggregate trade imbalances

	surplus	Δ exports	Δ imports
Brazil	17%	-15%	20%
China	21%	-17%	28%
EU	8%	-9%	6%
India	-4%	1%	-8%
Japan	28%	-18%	44%
RoW	-9%	6%	-11%
US	-22%	16%	-26%

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